

Radion mixing Effects in the Two -Doublet Model

+

(JL Hewett
TGR)

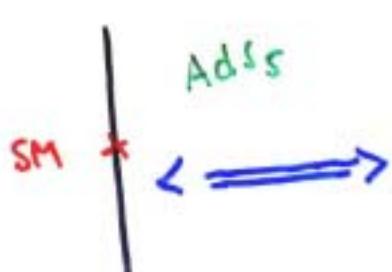
- Motivation
- Formalism
- Some Preliminary Results
- Summary / Conclusions

→ We consider only the radion of the
original Randall-Sundrum model
throughout ... all SM matter on TeV brane
(no brane terms, no)

TGRizz0
1/04

Recall

.. in RS



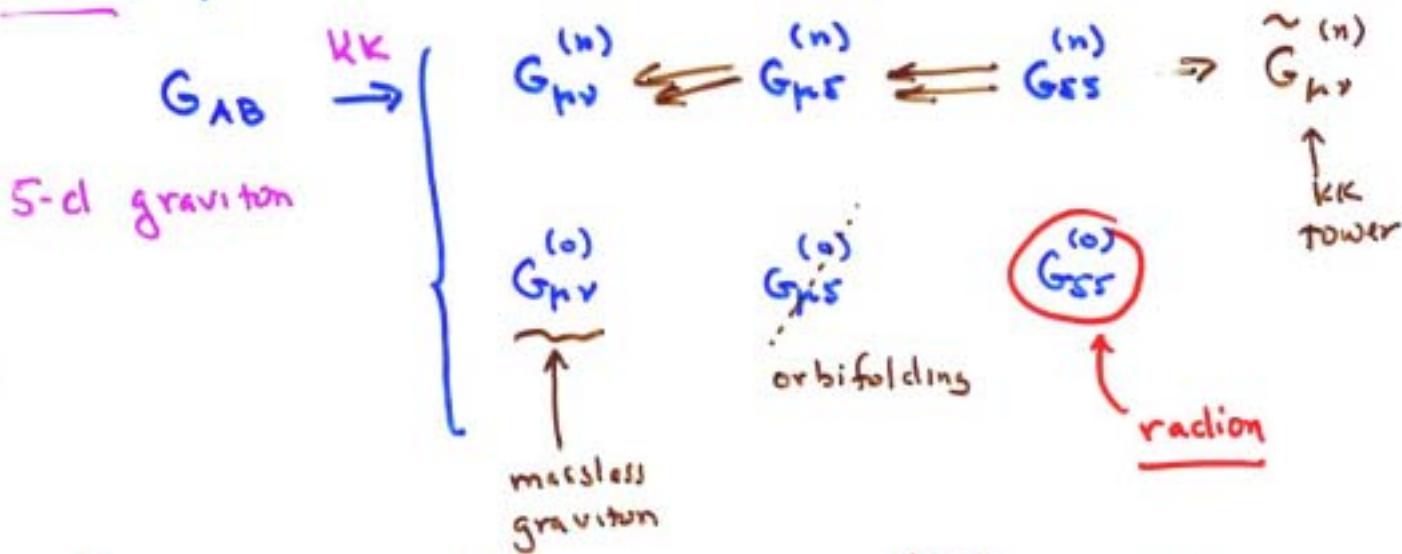
- The radion is a quantum excitation of the 2 brane separation

Tev
brane
 $y = \pi R$

Planck
brane
 $y = 0$

- RS is incomplete w/o a 'radion potential'
stabilization - e.g., {Goldberger
Wise
→ generates mr_o {~EWK scale}}

Where?



in 'unitary gauge': only $G_{\mu\nu}^{(0,n)}$ + radion are present in RS

Motivation : SUSY !!

- For various reasons, a SUSY version of RS
- has been considered by several sets of authors:
 - Altendorfer, Bagger + Nemeschansky :
hep-th/0003117
 - Gherghetta + Pomarol : hep-ph/0003129
 - ⋮ ⋮ ⋮ ⋮ ⋮

Since two Higgs doublets (at least) are required by SUSY ... it behoves us to examine this case

- Clearly this is more complicated than the single doublet model ...
 - What's new here ?
 - new signatures ?
 - modifications of SUSY-Higgs physics ...
 - just beginning ...

→ Generalize Csaki, Graesser + Krib (PRD63 065002)

$$S_{\text{mix}} = \int_{\text{Tev}}^{\text{Dim-4}} \sqrt{g_{\text{md}}} \underbrace{R(\text{gmd})}_{\text{Curvature}} \left[\begin{array}{c} \Sigma_1 H_1^+ H_1^- + \Sigma_2 H_2^+ H_2^- \\ + \Sigma_{12} H_1^+ H_2^- + h.c. \end{array} \right] \quad (\text{dim-4 interaction})$$

- $\Sigma_{1,2} + \Sigma_{12}$ are $O(1)$ dimensionless parameters
(assumed real here)

Expect (?) $\Sigma_1 = \Sigma_2$ but $\neq \Sigma_{12}$ in general

$$\mathcal{L}_5 = -6 \Omega^2 \left[\square \ln \Omega + (\nabla \ln \Omega)^2 \right] (\Sigma_1 H_1^+ H_1^- \dots)$$

$$\Omega \equiv e^{-\frac{-\gamma r_0/\sqrt{v}}{r}}, \quad \gamma = \frac{\sqrt{v}}{\Lambda \pi} \quad \Lambda \pi \stackrel{?}{\sim} \text{few TeV}$$

unmixed radion field

→ Expand to quadratic order in fields...

$$\mathcal{L} = -\frac{1}{2} h_0 \square h_0 - \frac{1}{2} m_{h_0}^2 h_0^2 - \frac{1}{2} H_0 \square H_0 - \frac{1}{2} m_{H_0}^2 H_0^2 - \frac{1}{2} r_0 \square r_0 - \frac{1}{2} m_{r_0}^2 r_0^2 - 3\sigma \gamma^2 r_0 \square r_0 + 6\gamma (\tau_H H_0 \square r_0 + \tau_h h_0 \square r_0)$$

h_0, H_0 = lightest (heaviest) neutral Higgs before
radio mixing { note A, H^\pm absent }
[CP]

- σ, τ_h, τ_H are functions of $\begin{cases} \tilde{\sigma}_{1,2}; \tilde{\sigma}_{12} \text{ and } t_p \\ S_{\alpha}, C_{\alpha} \end{cases}$

→ Rescale fields to remove kinetic mixing →
Canonically normalise fields

$$\left\{ \begin{array}{l} h_0 \rightarrow h' + 6\gamma \tau_h r'/z \\ H_0 \rightarrow H' + 6\gamma \tau_H r'/z \end{array} \right. \quad r_0 \rightarrow r'/z$$

$$Z = 1 + 6\gamma^2 (\sigma - 6(\tau_h^2 + \tau_H^2))$$

Then rotate $(h', H', r') \xrightarrow{\odot} (h, H, r)$ to
diagonalize the mass² matrix \Rightarrow the physical
basis, i.e., mass eigenstates

Problems: tooo many parameters... take h_0, H_0
from SUSY w/ $t_p = 10$, $M_A = 500 \text{ GeV}$ (e.g.)

$$A_t = A_b = -\mu = 1 \text{ TeV}, \quad \frac{m_{\tilde{t}_1} m_{\tilde{b}_1}}{2} = (1 \text{ TeV})^2$$

+ incorporate RC to masses etc $\left\{ \begin{array}{l} \text{Carone, Haber, Logan} \\ \text{+ mrenna PROFS} \end{array} \right.$

Assume $\gamma \sim 0.05, |\tilde{\sigma}_{12}/\tilde{\sigma}_1| \sim 0(1) \xrightarrow{\text{Sample results}}$

$$\sigma = \gamma_1 c_\beta^2 + \gamma_2 s_\beta^2 + 2\gamma_{12} c_\beta s_\beta$$

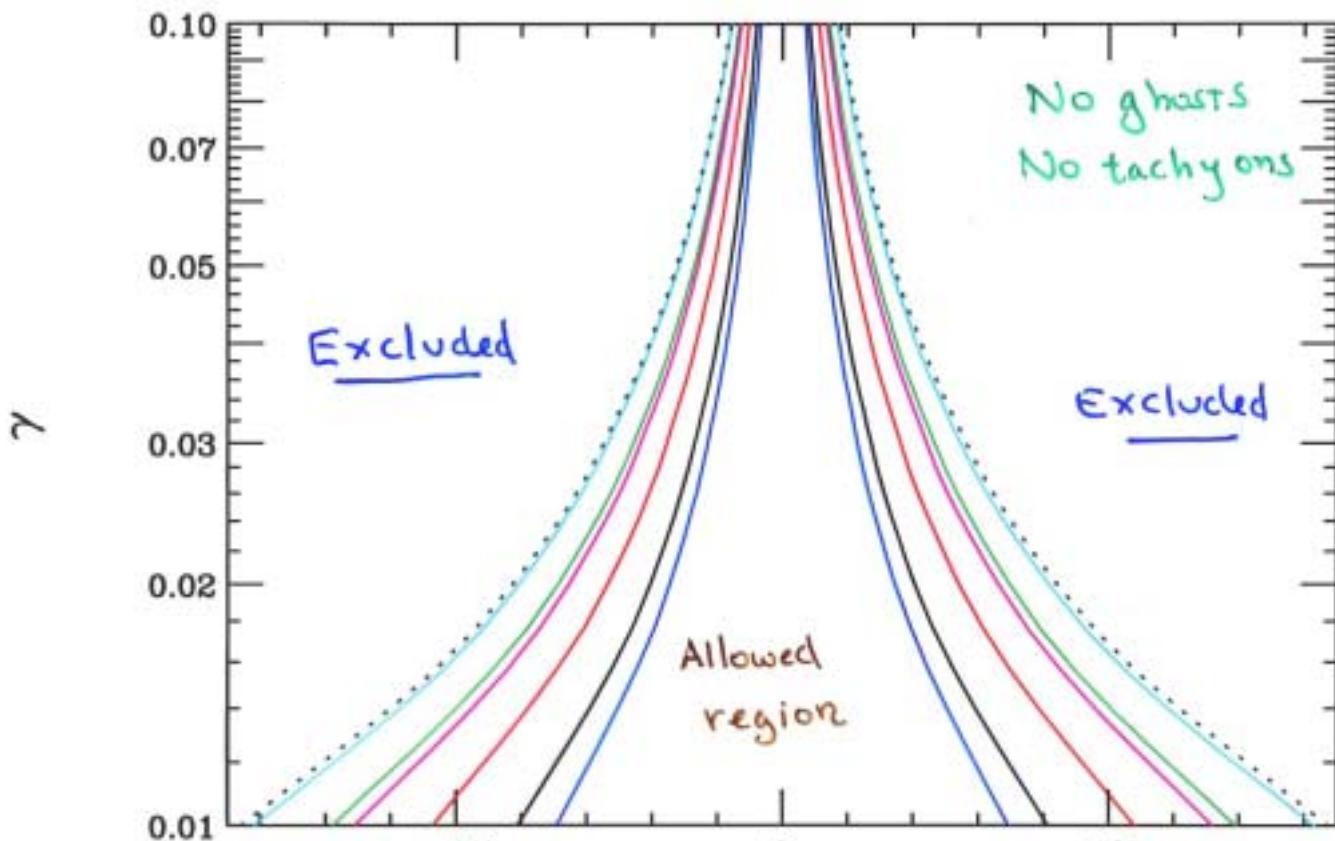
$$T_h = -s_\alpha (\gamma_1 c_\beta + \gamma_{12} s_\beta) + c_\alpha (\gamma_2 s_\beta + \gamma_{12} c_\beta)$$

$$T_H = c_\alpha (\gamma_1 c_\beta + \gamma_{12} s_\beta) + s_\alpha (\gamma_2 s_\beta + \gamma_{12} c_\beta)$$

$$c_\beta, s_\beta = \cos \beta, \sin \beta$$

$c_\alpha, s_\alpha = \cos \alpha, \sin \alpha$ - the h°, H° diagon.
angle

Parameter space restrictions



Red $\xi_{12} = \xi_1$

Green $\gamma_2 \xi_1$

Blue $2 \xi_1$

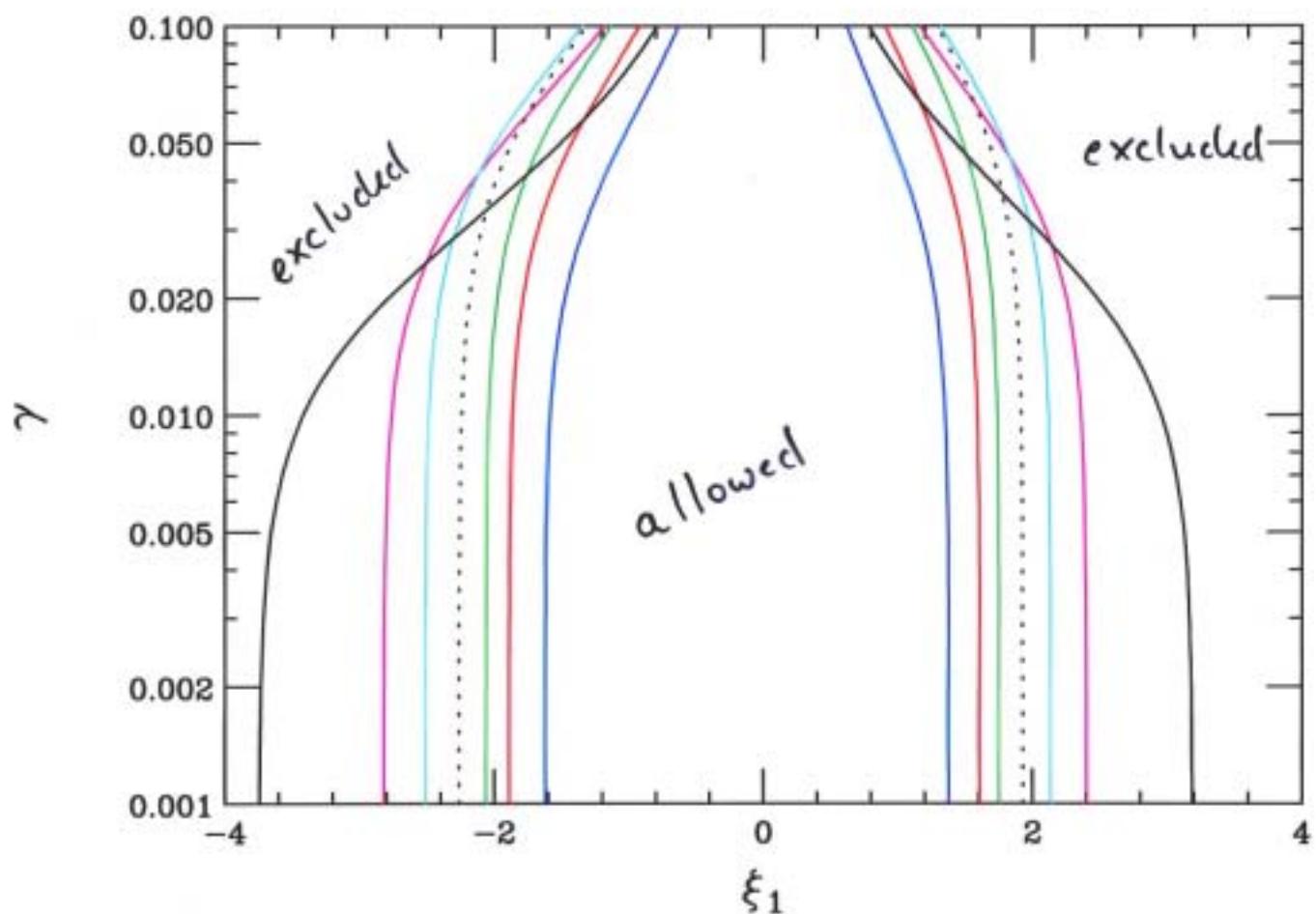
ξ_1

magenta $\xi_{12} = -\xi_1$

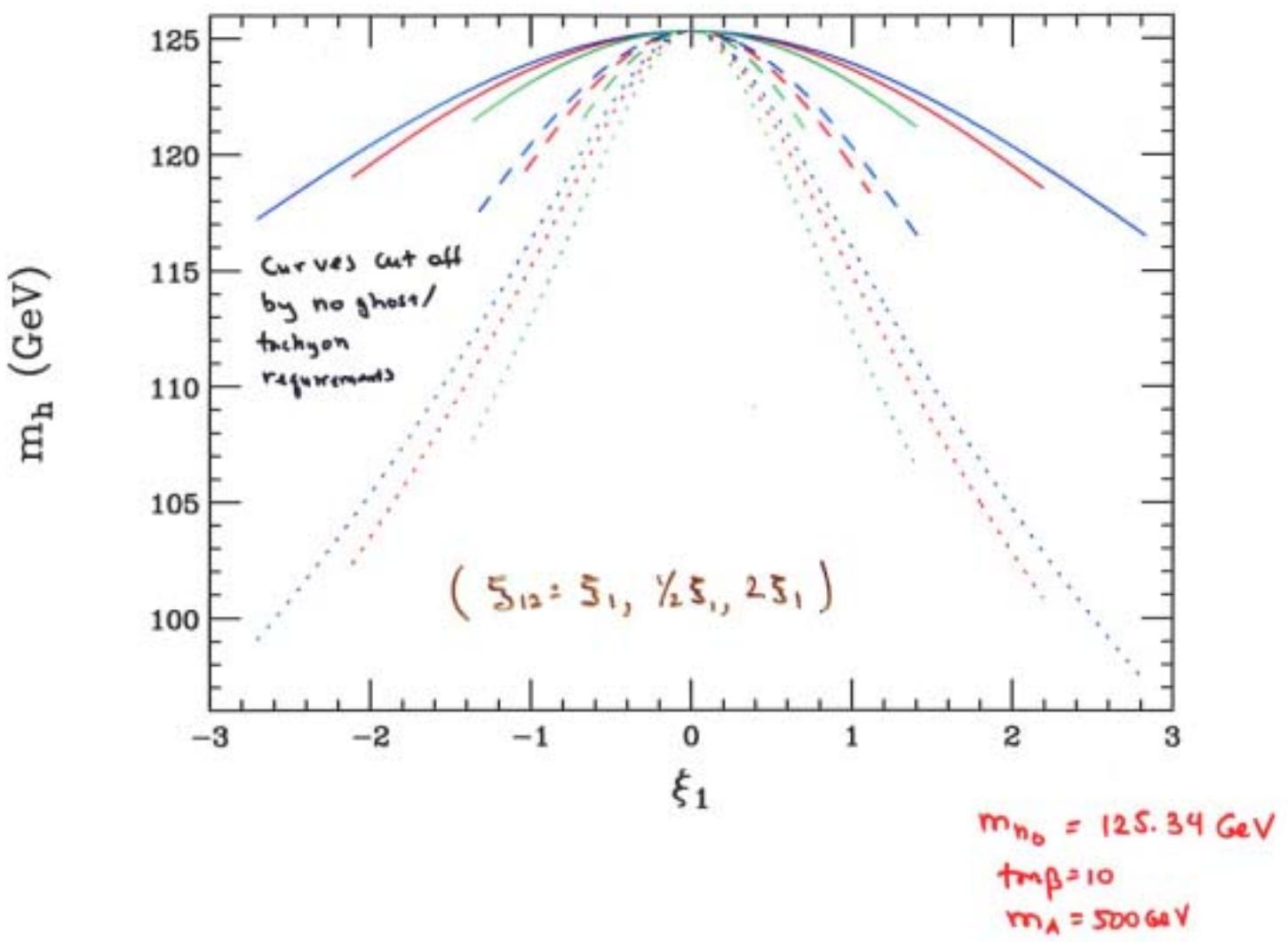
cyan $-\gamma_2 \xi_1$

solid dot 0

Unitarity in $WW \rightarrow WW$ to Λ_{π}

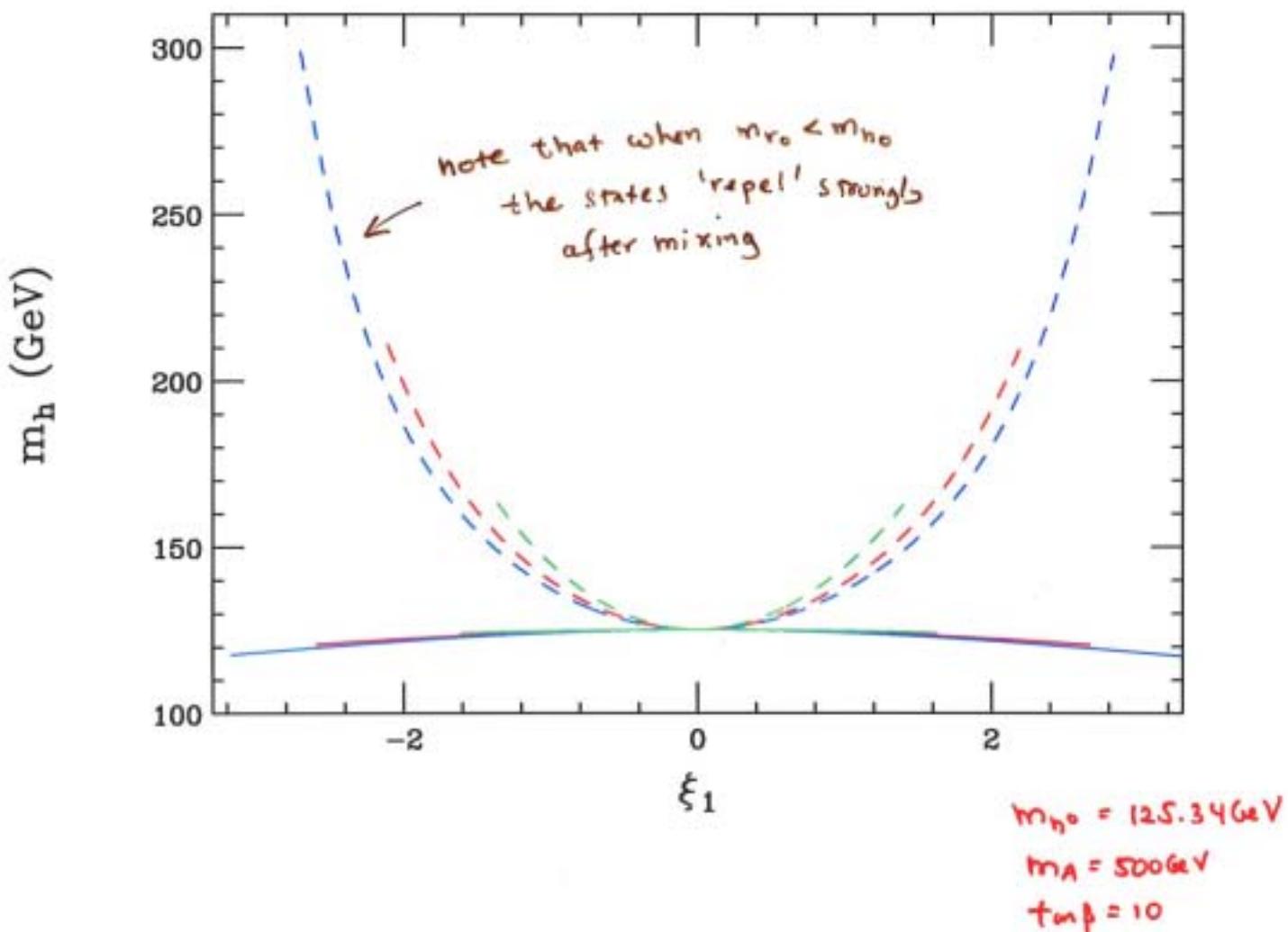


Solid: $m_{r_0} = 300 \text{ GeV}$ $\gamma = 0.05$ Dot $m_{r_0} = 150 \text{ GeV}$ $\gamma = 0.05$
 Dash : " " $= 0.1$

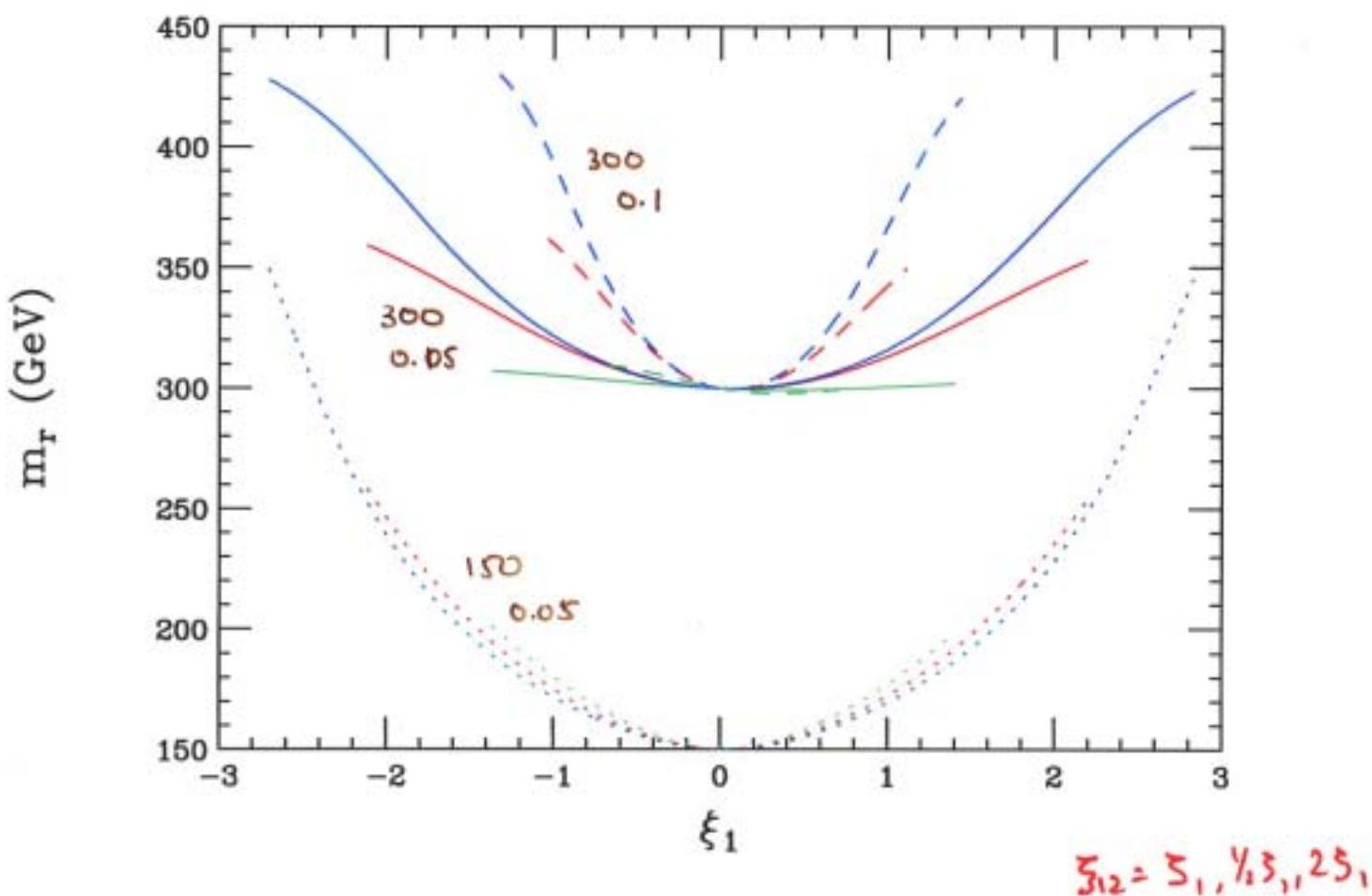


Solid : $m_{r_0} = 300$ $\gamma = 0.05$ $S_{12} = -\bar{s}_1, -\bar{y}_2 \bar{s}_1, -\bar{z}_1$

Dash : $m_{r_0} = 80$ $\gamma = 0.05$ $S_{12} = \bar{s}_1, \bar{y}_2 \bar{s}_1, \bar{z}_1$

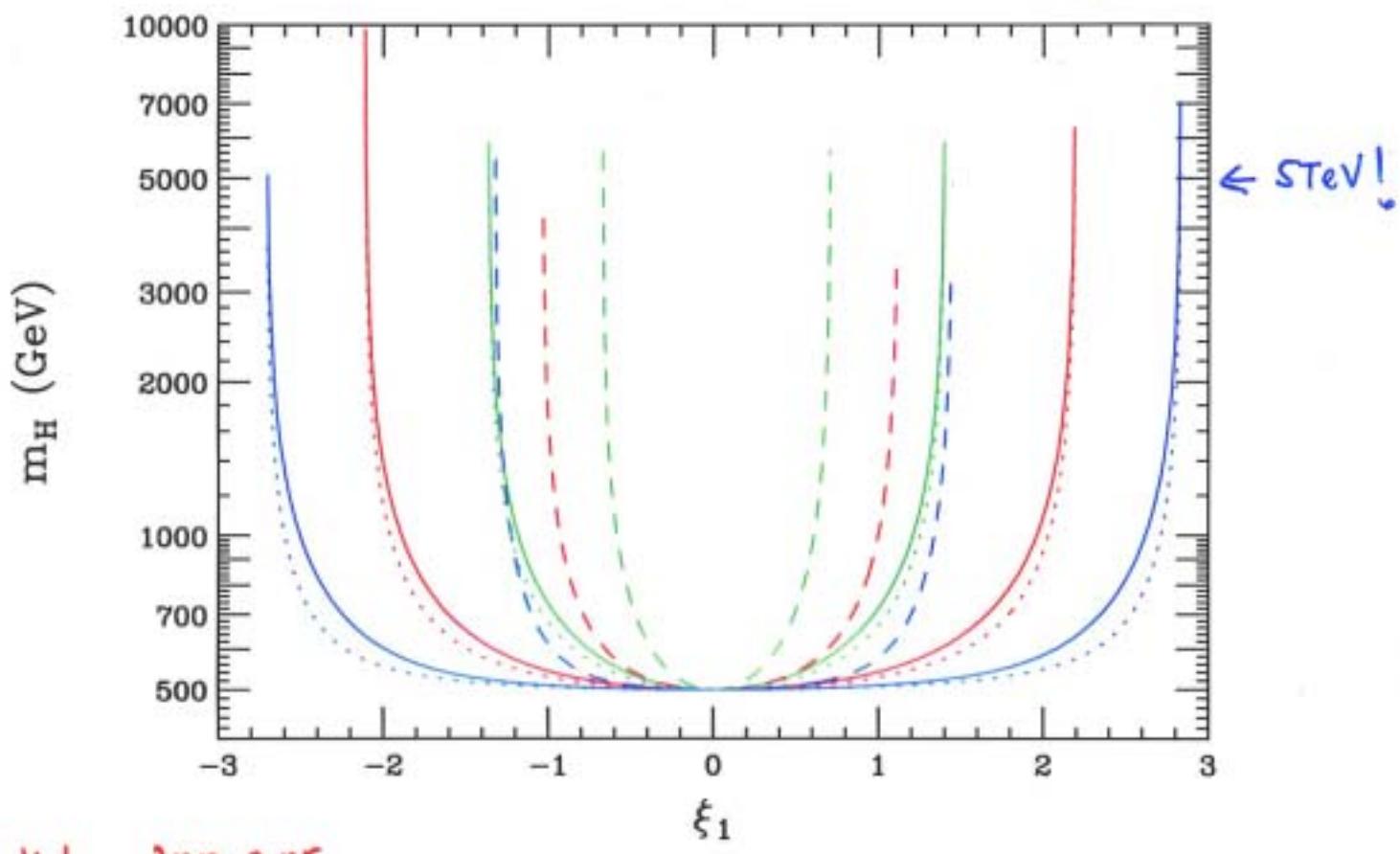


Radion mass



'Heavy' Higgs mass

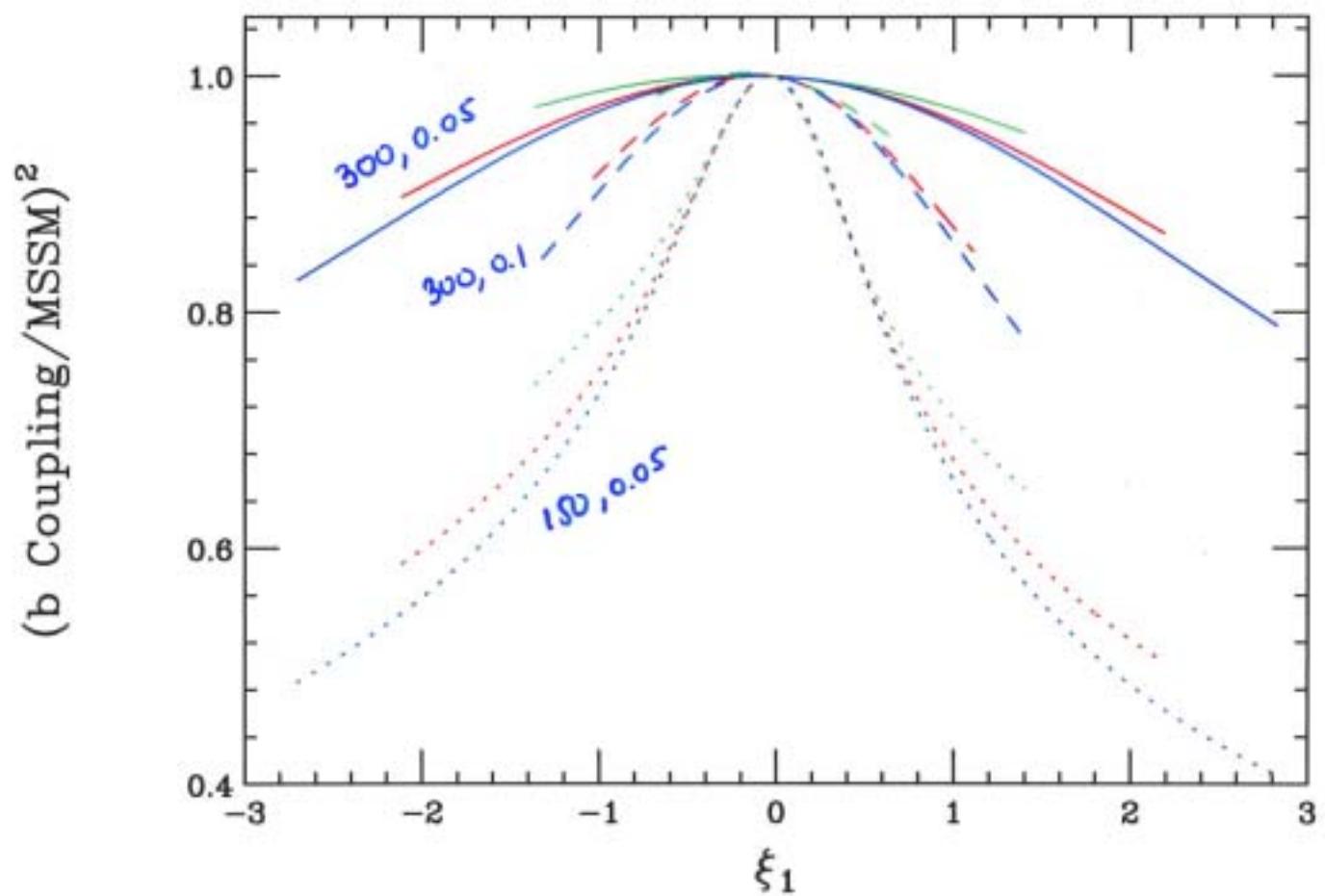
Strongly pushed
Upwards



Solid 300, 0.05
Dash 300, 0.1
Dot 150, 0.05

$\xi_{12} = \xi_1, \xi_1/2, 2\xi_1$

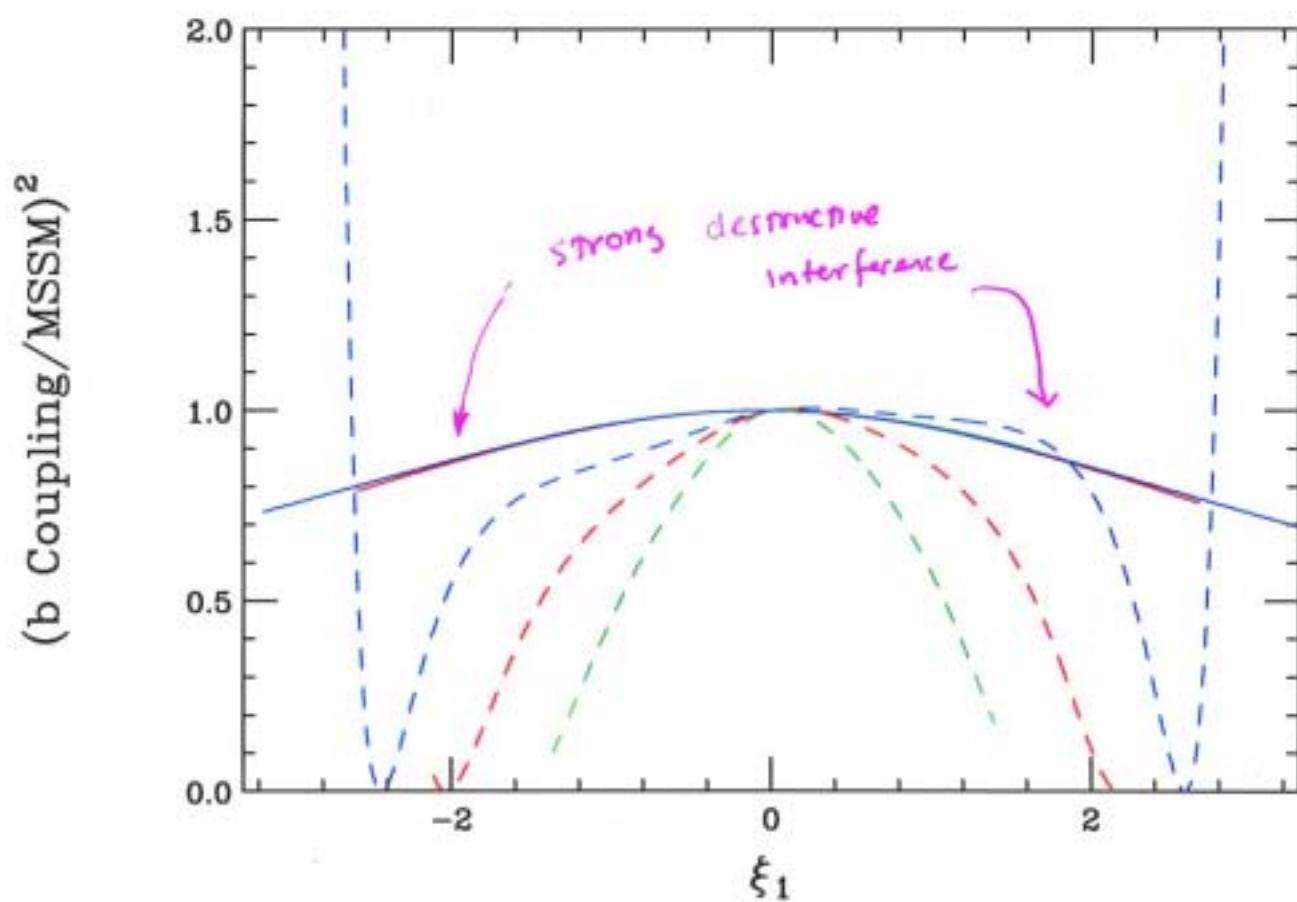
$h b\bar{b}$ coupling



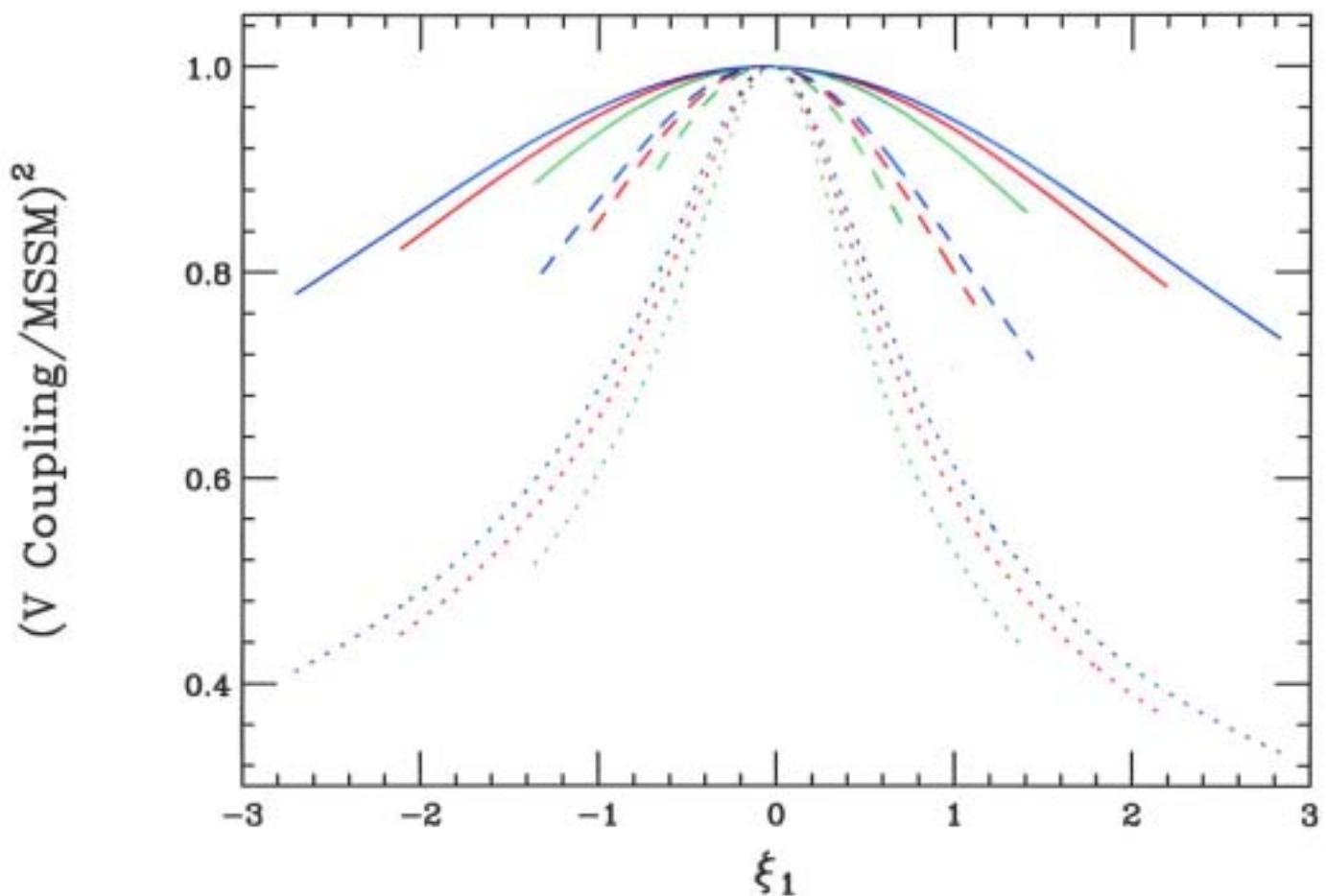
$$\Sigma_{12} = \Sigma_1, \gamma_2 \Sigma_1, 2\Sigma_1$$

$h b\bar{b}$ coupling

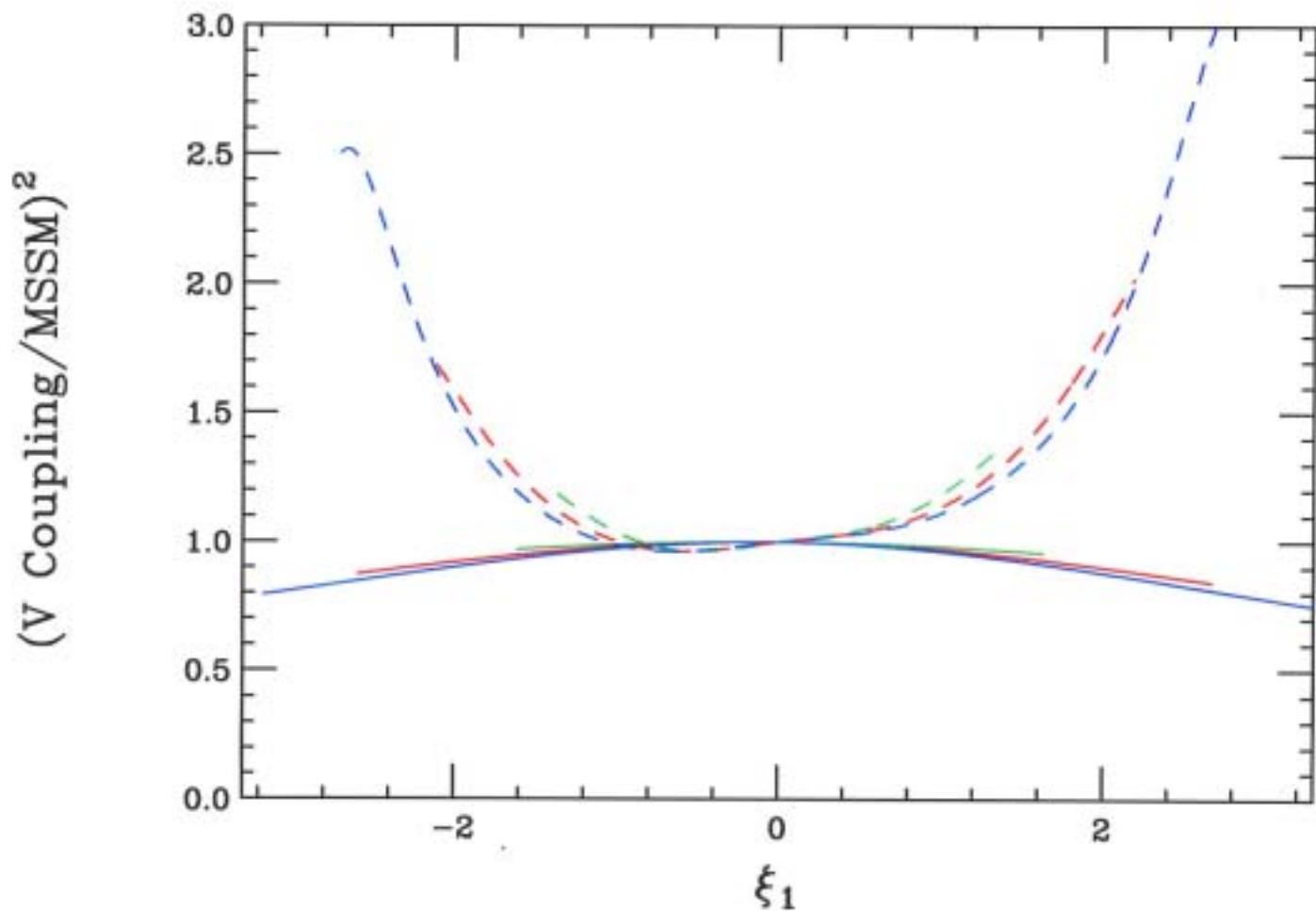
$\left\{ \begin{array}{l} \text{Solid } m_{r_0} = 300, \gamma = 0.05 \ (\xi_{12} \text{ neg } \xi_1) \\ \text{Dash } m_{r_0} = 80, \gamma = 0.05 \end{array} \right.$



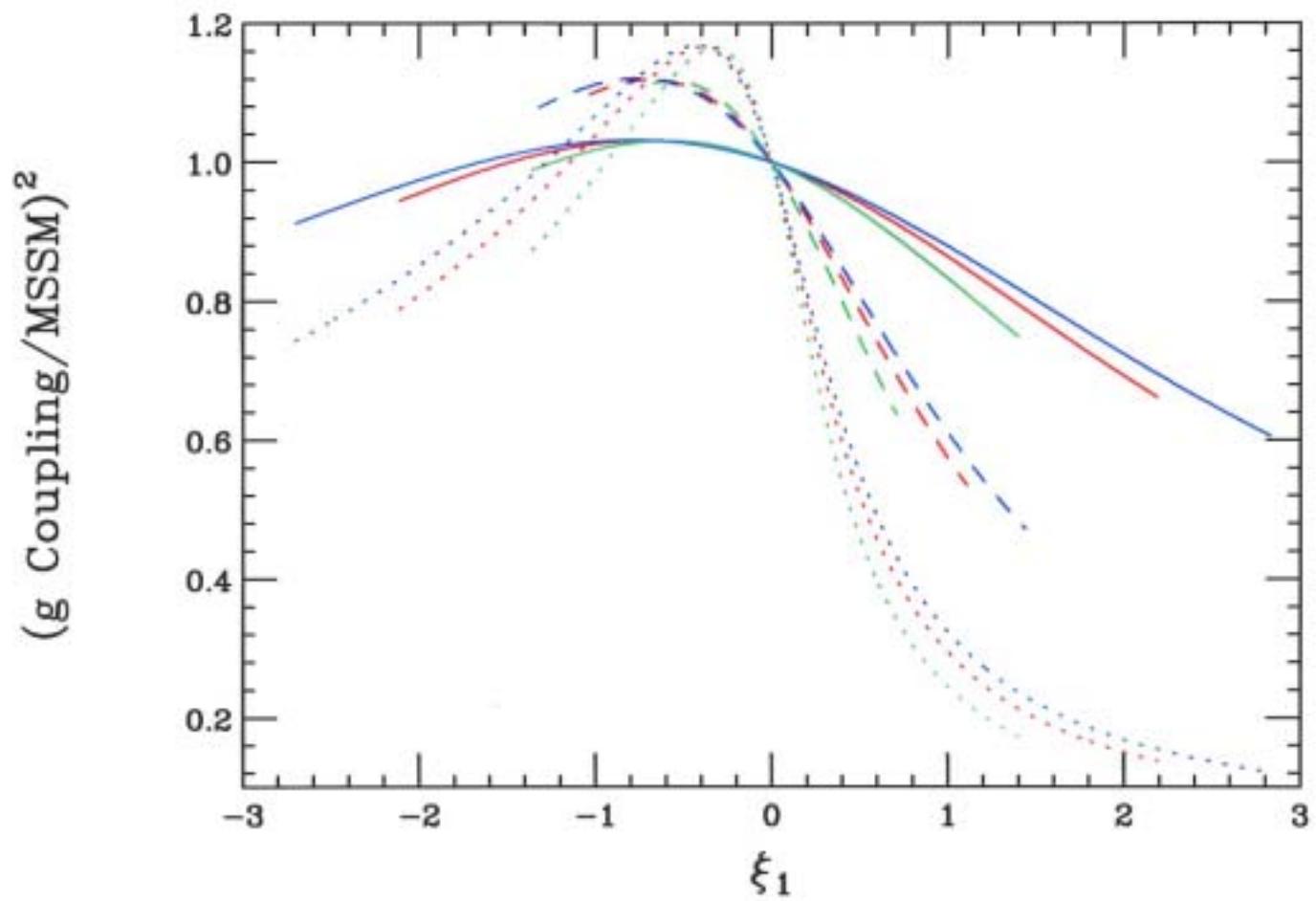
h VV coupling



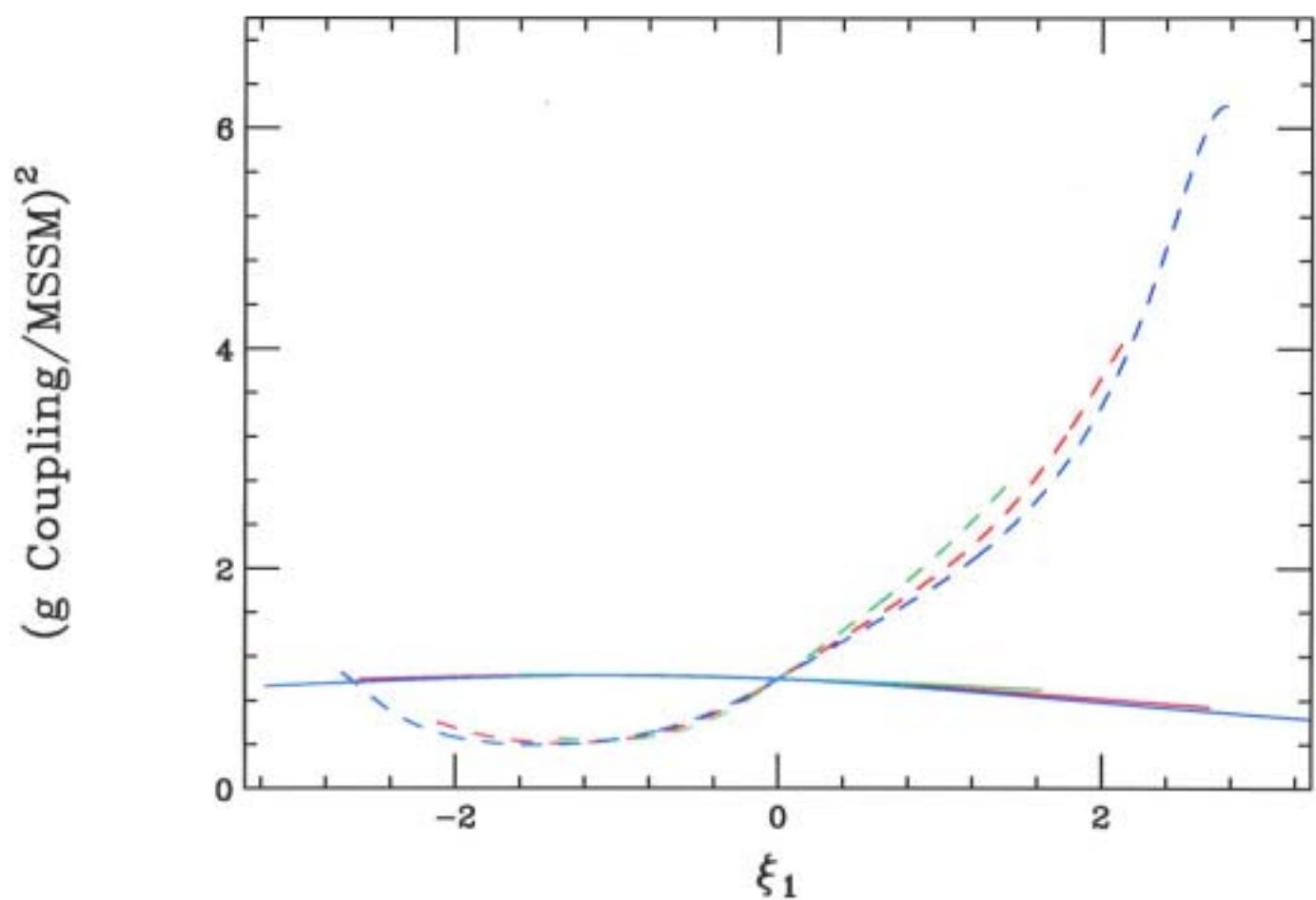
hVV coupling



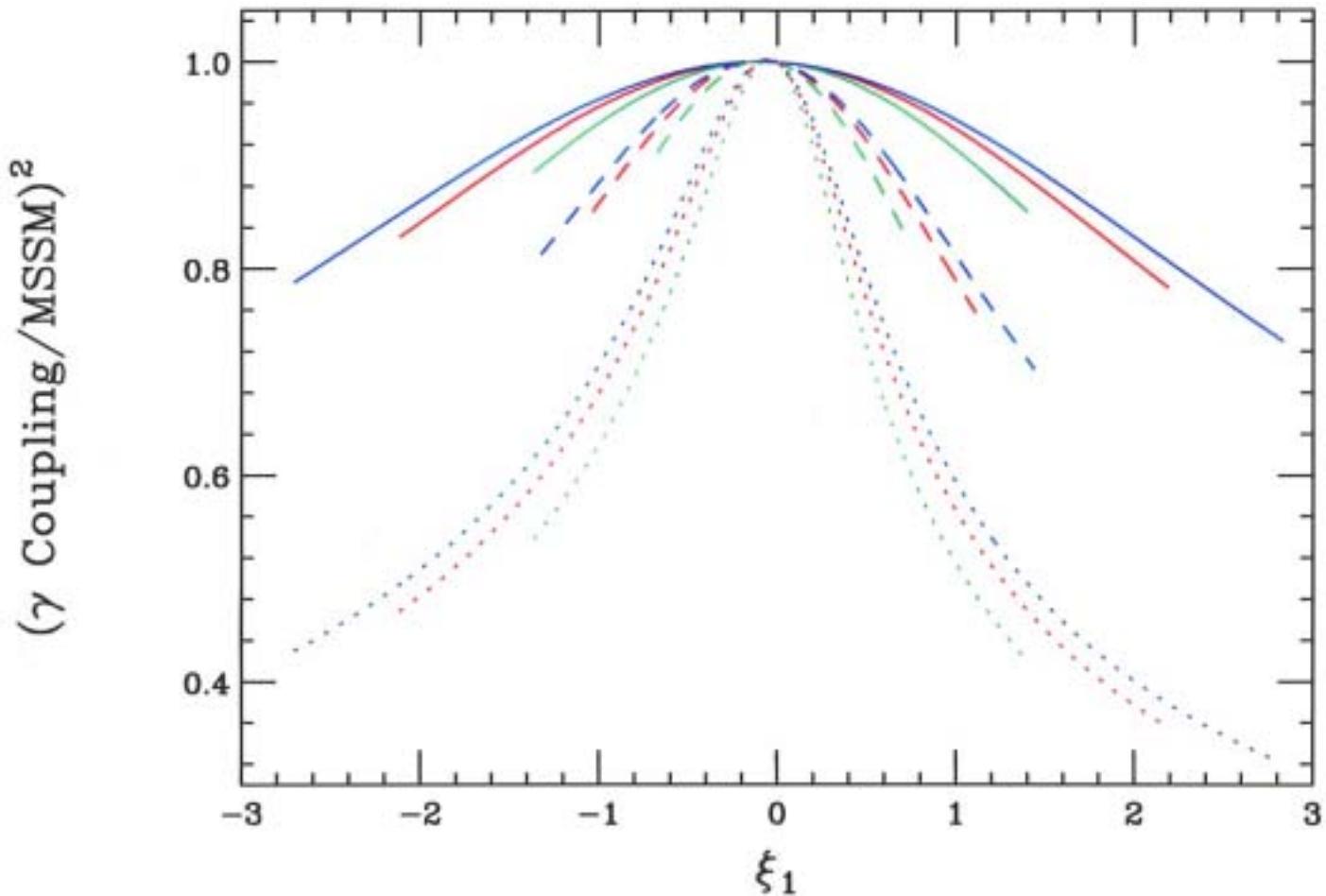
hgg coupling



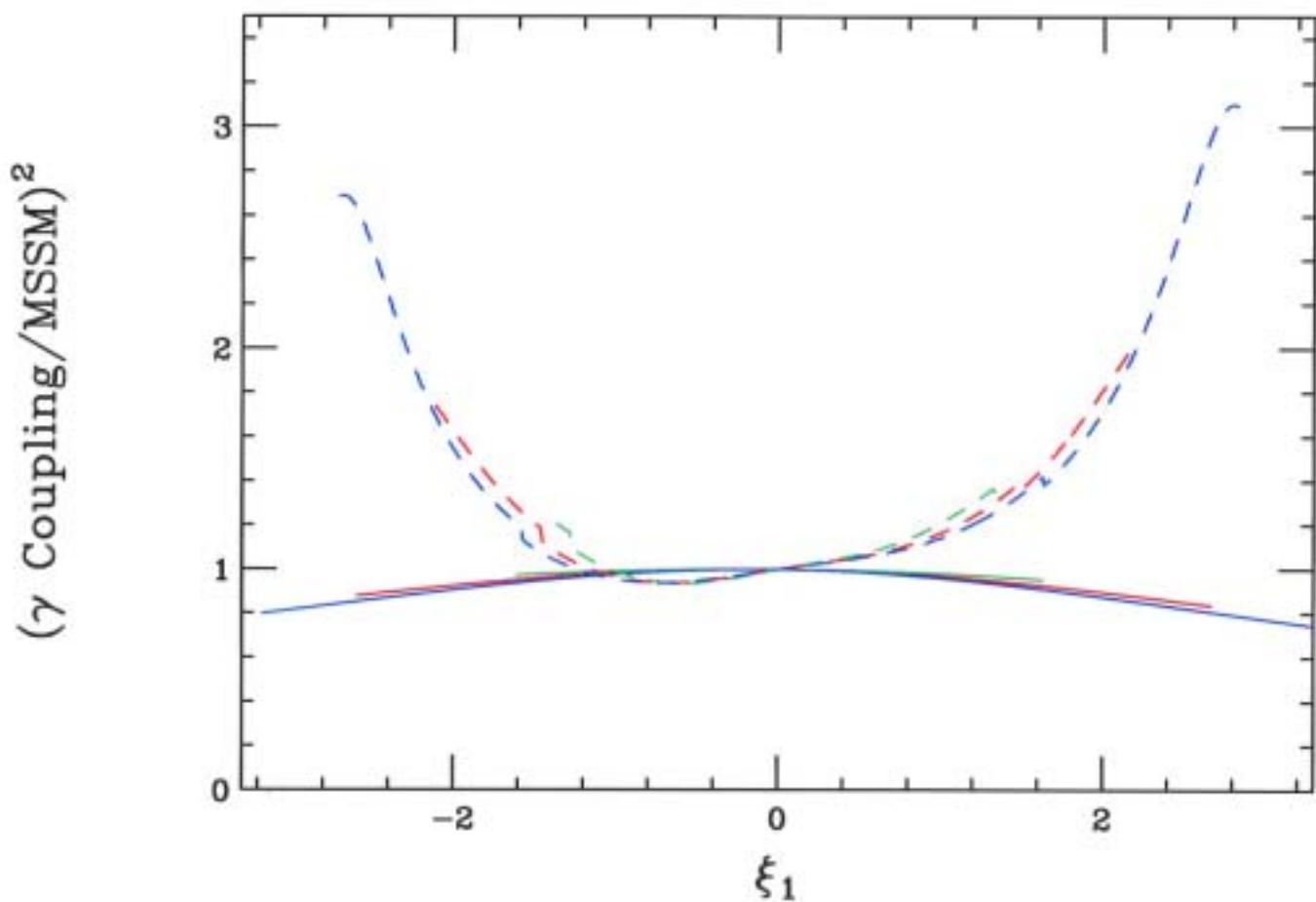
hgg coupling

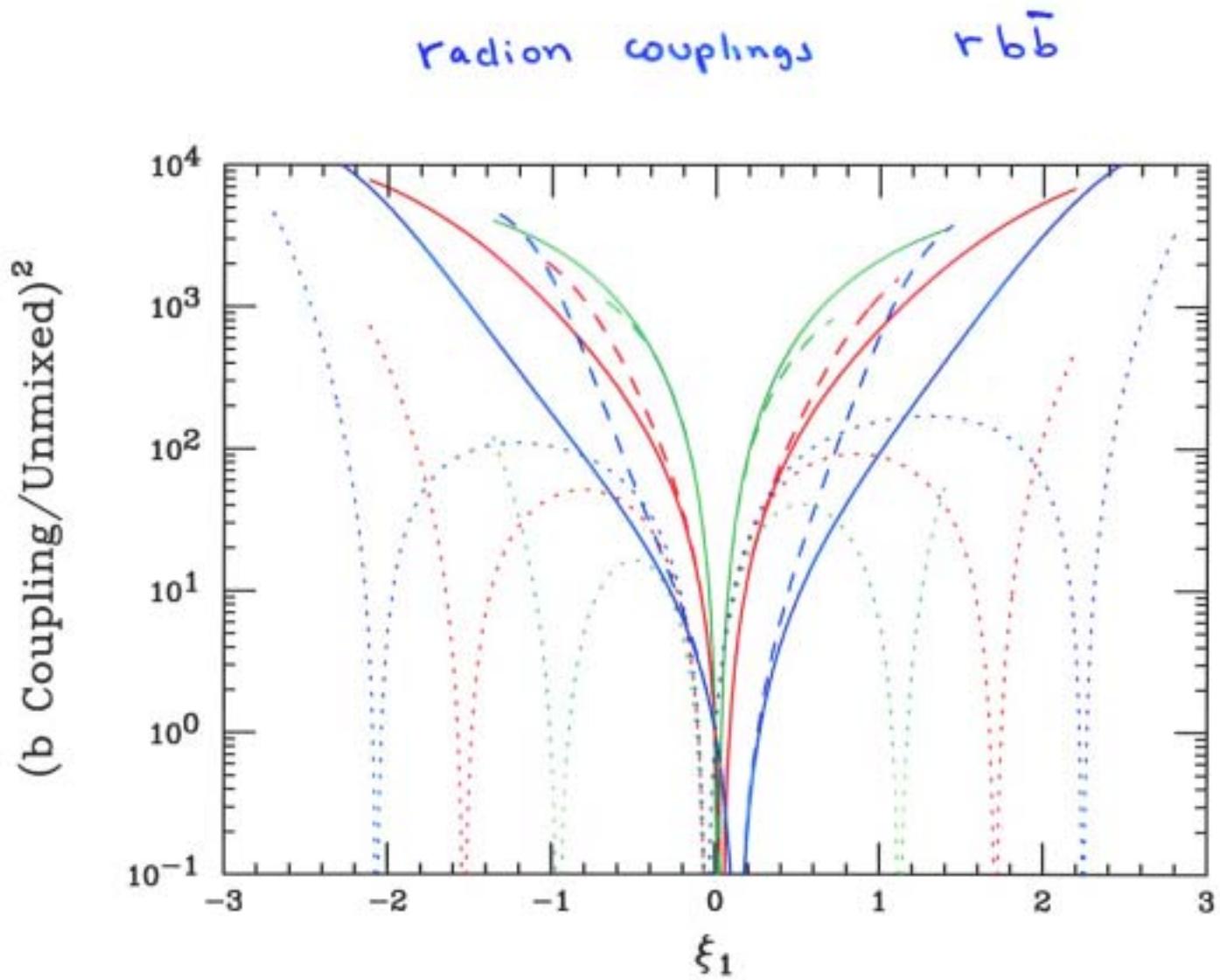


hγγ coupling

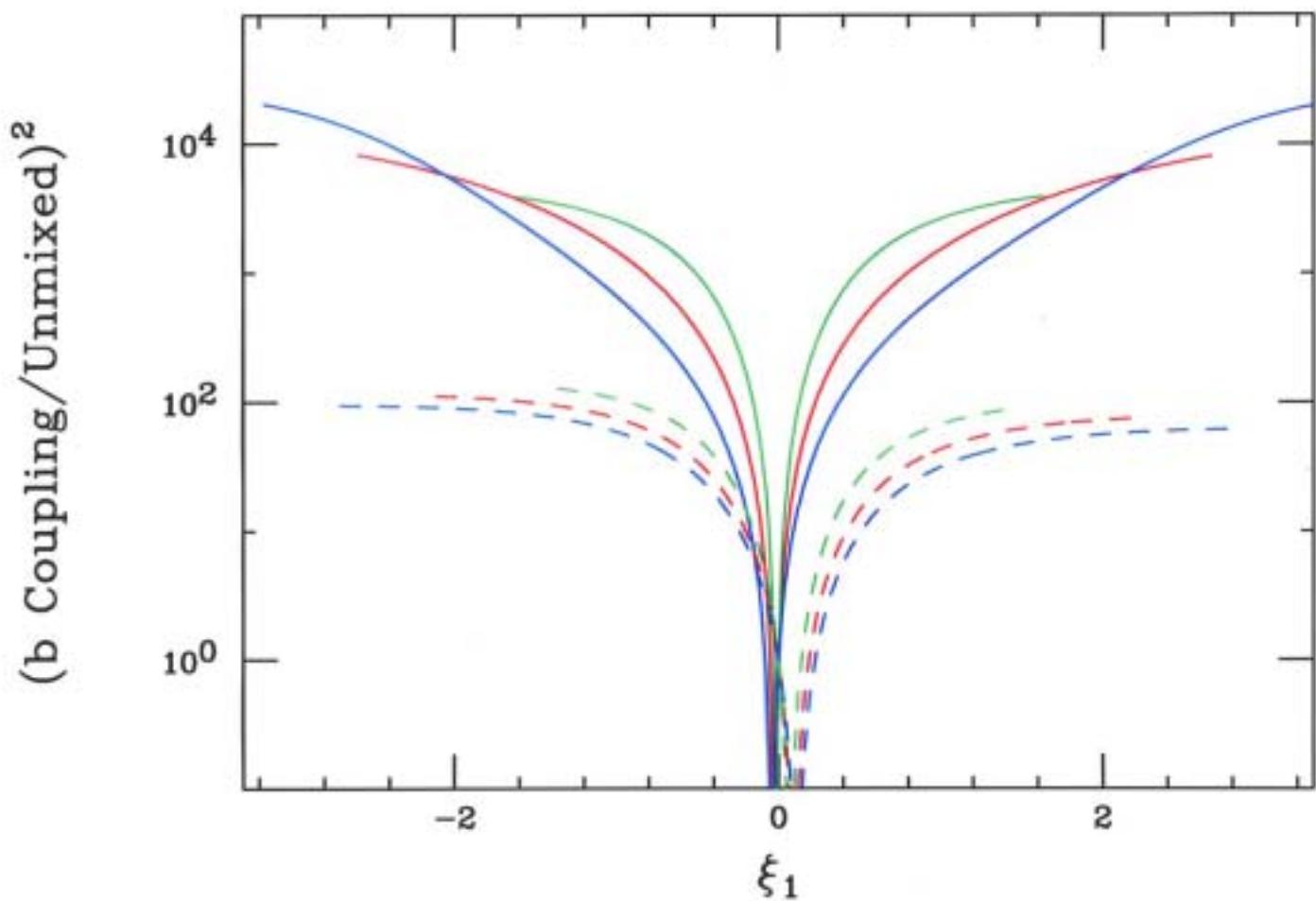


h 88 coupling

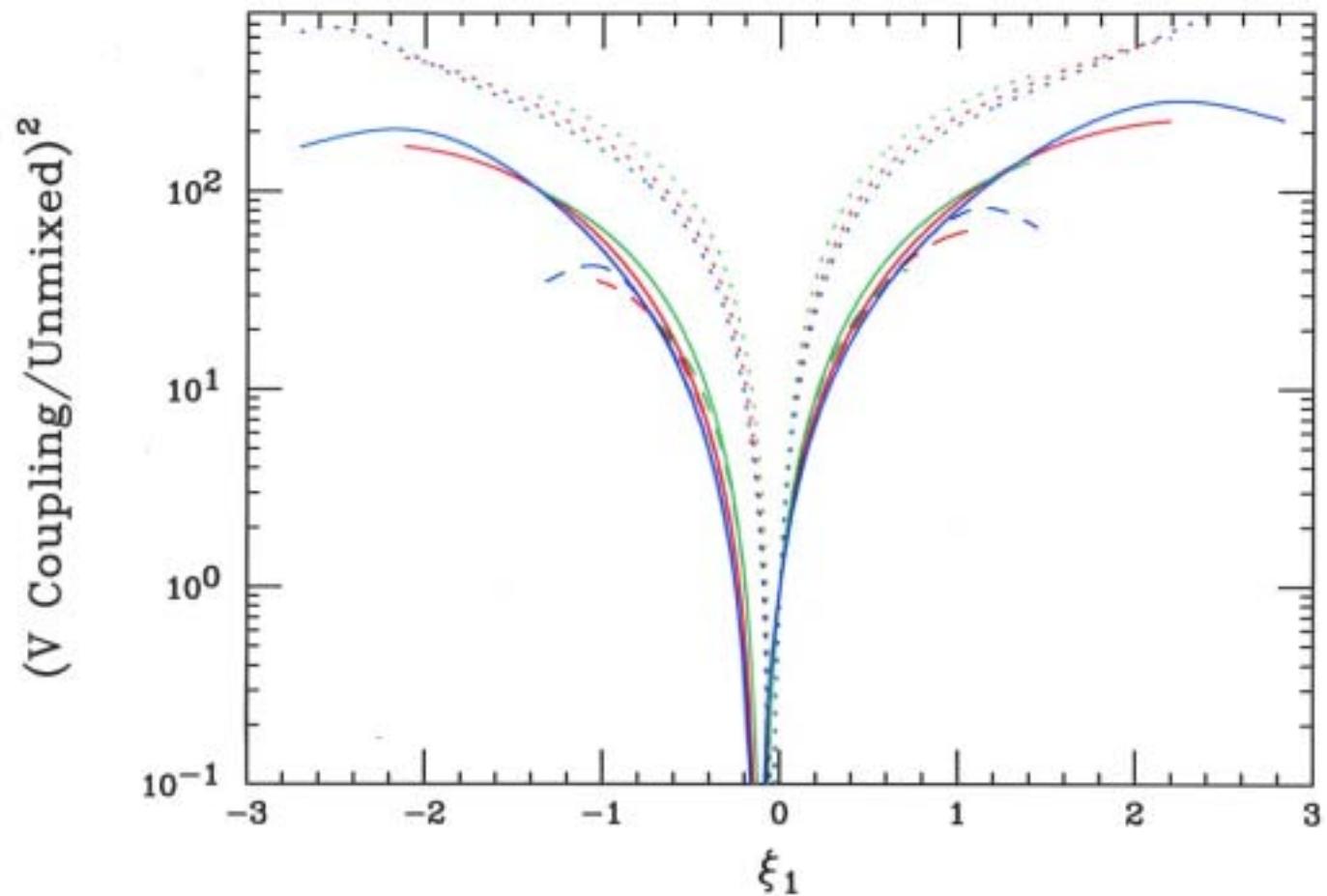




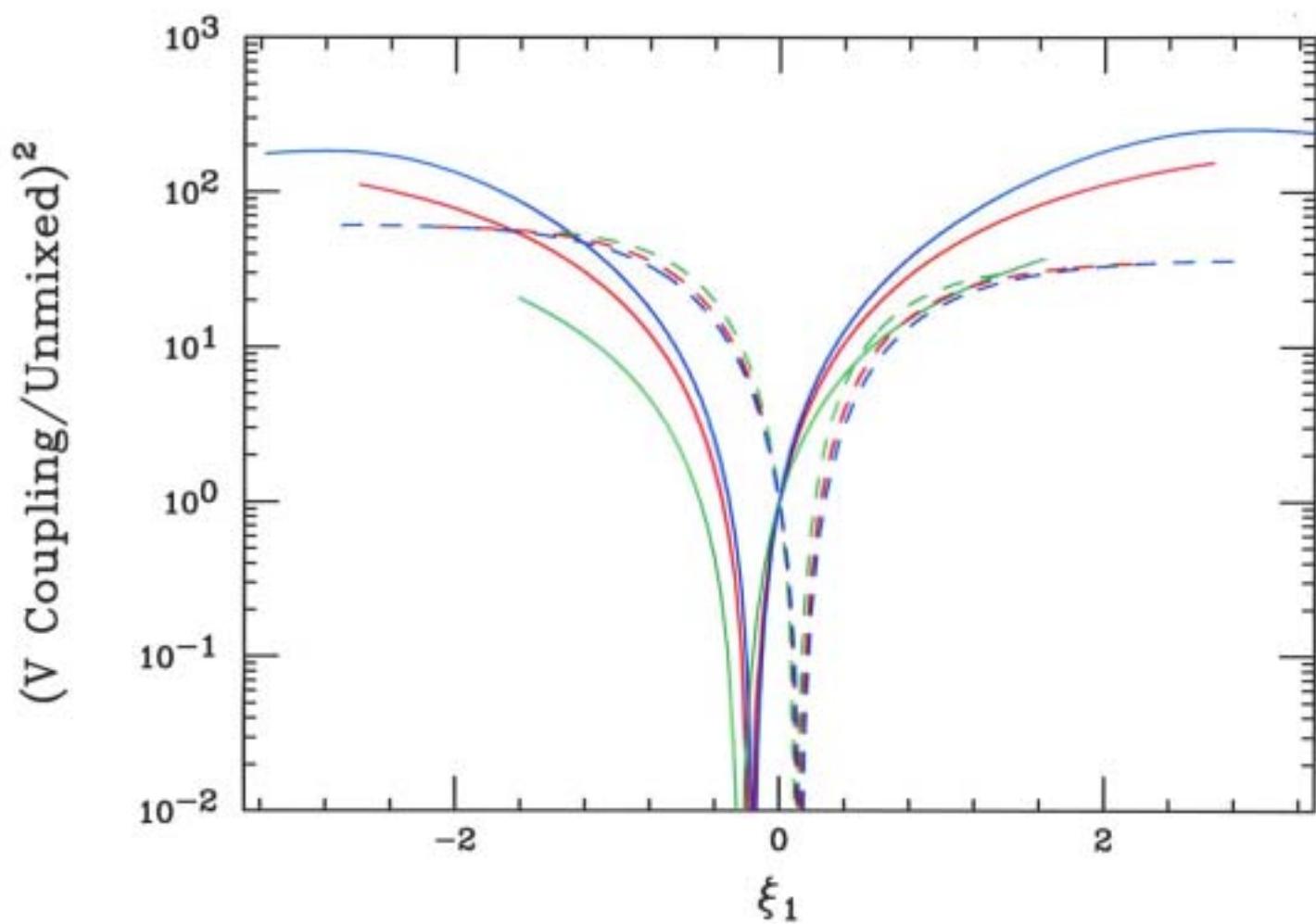
r_{bb}^{-1}



rVV coupling



rvv coupling



Summary + Conclusions

- Motivated by SUSY RS, we need to explore radion - TD mixing
- Unfortunately the parameter space is LARGE + we've only begun looking
- As expected, variations in masses + couplings are greater than in the one-doublet case
- Plenty of work remains...